(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
7 July 2005 (07.07.2005)

PCT

(10) International Publication Number
WO 2005/062234 A1

(51) International Patent Classification[7]: G06K 7/10, 19/06

(21) International Application Number:
PCT/US2004/013101

(22) International Filing Date: 28 April 2004 (28.04.2004)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/526,604 4 December 2003 (04.12.2003) US

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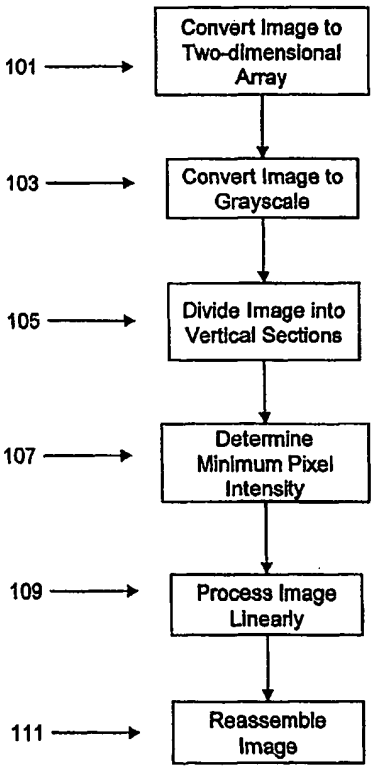
(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PL, PT, RO, SE, SI,

[Continued on next page]

(54) Title: SECTION BASED ALGORITHM FOR IMAGE ENHANCEMENT



(57) Abstract: This present invention discloses a system and method for enhancing images of barcodes and other similar objects taken by the digital camera connected to or embedded in a mobile device. This filter works by converting (101, 103) the image into sections and finds the pixels of minimum intensity (107) in each section of the image. This minima is used to calculate cut-off values (109) for thresholding. After thresholding, the image is reassembled (111) from its divided sections.

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SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declaration under Rule 4.17:

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii)) for the following designations AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, UZ, VC, VN, YU, ZA, ZM, ZW, ARIPO patent (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG)*

Published:

— *with international search report*

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

SECTION BASED ALGORITHM FOR IMAGE ENHANCEMENT

TECHNICAL FIELD OF THE INVENTION

The present invention relates generally to the field of image enhancement algorithms. More specifically, the present invention utilizes a proprietary algorithm designed to enhance image of barcodes and other similar objects.

BACKGROUND ART

Barcodes have been utilized for identifying and pricing objects for more than thirty years. Most typically, barcodes are used in retail to identify the item of merchandise. For example, a gallon of milk may contain a barcode that, when scanned, will notify the cashier of the price of the milk.

Yet in recent years, barcodes have acquired new purposes as computers and barcode scanners have become more portable. The circuitry required to scan a conventional one-dimensional barcode can now be housed in a device as small as a typical keychain. As a result, many mobile telephones, personal digital assistants ("PDAs"), and pagers can be retrofitted with or connected to a laser-based scanning device. This allows the mobile device to function as a scanner capable of storing hundreds or thousands of scanned barcodes.

Currently, many cell phones and mobile devices are available with built-in cameras. The explosion of the availability of affordable digital cameras and their inclusion into mobile devices is driven by several factors. One of the most important is the recent availability of inexpensive image sensors based on CMOS technology. The cameras on these devices provide a means for capturing the barcode information which was

previously only accessible via a laser-based scanner. Decoding barcode images from digital cameras included in mobile devices presents several difficult problems. These problems go well beyond the challenges addressed in commercial barcode readers. Some of these problems are addressed below:

Lighting:

Most mobile devices with integrated digital cameras do not have built-in flashes and rely solely on the ambient light for illumination. This can cause the image to be underexposed or overexposed depending upon the intensity of the ambient light.

Focus:

Digital cameras for portable devices are usually designed to work at a variety of distances. The need for a wider range of focus in cameras results in a trade off between the cost of the lens component and the sharpness of a typical image.

Low-cost lens components:

In order to meet cost constraints of many portable device markets, manufacturers often compromise on the optical quality of camera lenses. This can present decoding technology with a different set of challenges from the simple focal length based focus problem noted above. Low-cost lens components can produce image distortions that are localized to a specific region or form a changing gradient across the image.

Limited resolution:

The cost of a digital imaging CMOS sensor increases as the number of image pixels increases. Although the Asian market has seen the release of general purpose consumer devices like PDAs and cell phones with "megapixel" image resolution, the European and North American markets are now only seeing their emergence.

Lower resolution images contain less detail and usually require further processing to be useful.

Based on the aforementioned described problems with mobile digital imaging, there clearly exists a need for an image enhancement algorithm which can compensate for many of these shortcomings. Such an algorithm would allow many more of the images captured by a digital camera to be useful, especially if the images are intended for optical decoding.

DISCLOSURE OF THE INVENTION

The present invention provides an algorithm designed to enhance images of barcodes and other similar objects. First, the sharpening algorithm converts the gray-scale barcode image is broken down into a two-dimensional array. Each entry in the two-dimensional array stores the intensity of a single pixel. The image is then divided into an equal number of vertical sections. The number of sections ("ns") is equal to the width of the image (in pixels) divided by the desired width of the sections ("ws"). The width of the sections can either be user defined or automatically defined depending upon the size of the image. This converts the image to a three-dimensional array since each pixel also has an assigned section.

After the image has been divided into sections, the sharpening algorithm determines the minimum intensity of a pixel in each section. The image is then processed linearly section by section. This is done by assigning a pixel intensity of "black" to all pixel intensities which are below a threshold black level. The threshold black level is user-defined and may be changed for each image or section being processed. In contrast, all pixel intensities having a pixel value above a threshold white

value are assigned a pixel intensity corresponding to "white."

A pixel is also assigned a "black" intensity if:

1. The value of the pixel lies within a predetermined range of the minimum pixel intensity for that section; or
2. The intensity of pixels surrounding a certain pixel has an intensity that lies within the predetermined range of minimum pixel intensity for that section.

After the image of the barcode has been processed, the sharpening algorithm renders the processed image sections back into an image.

Therefore, it is an object of the present invention to provide an image enhancement algorithm capable of sharpening a barcode image for optical decoding.

An additional object of the present invention is to provide an image enhancement algorithm which applies a distinct thresholding to each section of the image.

Another object of the present invention is to provide an image enhancement algorithm which utilizes the minimum intensity pixel of each section to determine the cut-off value for thresholding.

It is also an object of the present invention to provide an image enhancement algorithm which converts the image to grayscale prior to processing.

These and other objects of the present will be made clearer with reference to the following detailed description and accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 depicts a flowchart showing the process utilized by the ScanZoom software to sharpen an image.

FIG. 2A depicts a typical barcode image acquired using a digital camera.

FIG. 2B depicts the barcode of FIG. 5B after it has undergone sharpening utilizing the sharpening filter depicted in FIG. 2A.

BEST MODE(S) FOR CARRYING OUT THE INVENTION

The following presents a detailed description of a preferred embodiment (as well as some alternative embodiments) of the present invention. However, it should be apparent to one skilled in the art that the described embodiment may be modified in form and content to be optimized for a wide variety of situations.

With reference first to FIG. 1, shown is a flowchart depicting the steps of the image enhancement algorithm of the present invention. The image enhancement algorithm has been shown to be particularly effective for sharpening images containing barcodes. First, the sharpening algorithm converts the barcode image into a two-dimensional array in step 101. Each entry in the two-dimensional array stores the intensity of a single pixel. The image can now be described as a function as follows:

$$\text{Image} = \sum_{x=0}^{n-1} \sum_{y=0}^{m-1} f(x, y)$$

where n is the image width and m is the image height. The image is then converted to a grayscale image in step 103 by mapping each pixel to its grayscale representative. In the preferred embodiment, this is done utilizing a standard color to grayscale filter. The image is then divided into an equal number of vertical sections in step 105. The image can then be represented as follows:

$$\text{Image}_{(\text{section})} = \sum_{n=0}^{ns} \sum_{x=0}^{ws} \sum_{y=0}^{m-1} f(x, y) \quad \{\text{where } y=m \mid m \geq 0\}$$

where ns is the number of sections and ws is the desired width of the sections. The number of sections ("ns") is equal to the width of the image (in pixels) divided by the desired width of the sections ("ws"). The width of the sections can either be user defined or automatically defined depending upon the size of the image. This converts the image to a three-dimensional array since each pixel also has an assigned section.

After the image has been divided into sections, the sharpening algorithm determines the minimum intensity of a pixel in each section in step 107. The image is then processed linearly section by section in step 109. This is done by assigning a pixel intensity of "black" to all pixel intensities which are below a threshold black level. The threshold black level is user-defined and may be changed for each image or section being processed. In contrast, all pixel intensities having a pixel value above a threshold white value are assigned a pixel intensity corresponding to "white."

A pixel is also assigned a "black" intensity if:

- The value of the pixel lies within a predetermined range of the minimum pixel intensity for that section; or
- The intensity of pixels surrounding a certain pixel has an intensity that lies within the predetermined range of minimum pixel intensity for that section.

After the image of the barcode has been processed in step 109, the sharpening algorithm renders the processed image sections back into an image in step 111. An

example input and output barcode which have been processed by the aforementioned sharpening algorithm are shown in FIG. 2A and FIG. 2B, respectively. The outputted image of FIG. 2B has a much higher chance of being properly decoded than the inputted image of FIG. 2A.

While the foregoing embodiments of the invention have been set forth in considerable detail for the purposes of making a complete disclosure, it should be evident to one skilled in the art that multiple changes may be made to the aforementioned description without departing from the spirit of the invention.

CLAIMS

We claim:

1. A method of enhancing an image comprising the steps of:

converting the image to a two-dimensional array;

converting said image to grayscale;

dividing said image into vertical sections;

determining the minimum pixel intensity in each of said sections;

assigning all pixels in said image having an intensity below a first threshold an intensity corresponding to black;

assigning all pixels in said image having an intensity above a second threshold an intensity corresponding to white;

assigning a pixel in a section an intensity corresponding to black if the intensity of the pixel lies within a predetermined range of the minimum pixel intensity for that section; and

assigning a pixel in a section an intensity corresponding to black if the intensity of pixels surrounding said pixel lie within a predetermined range of minimum pixel intensity for said section; and

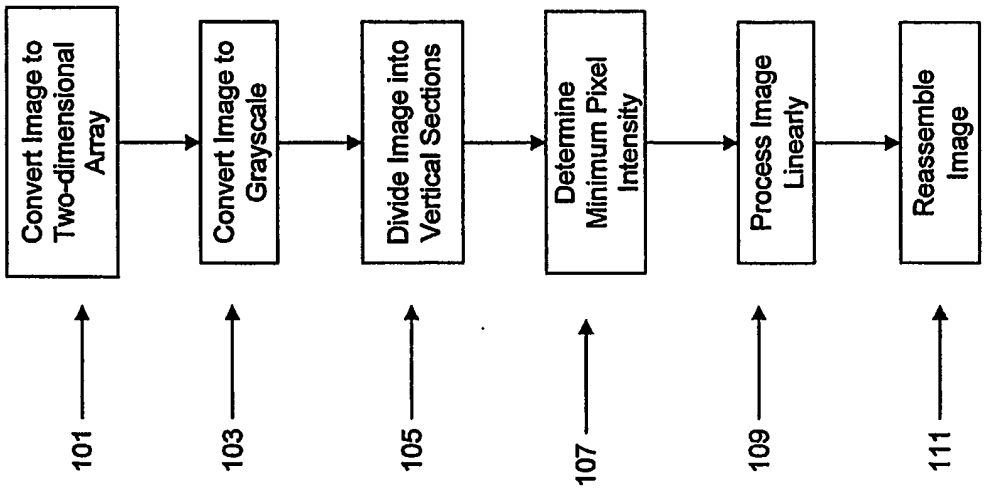
recombining said image sections.

2. A method for enhancing an image according to Claim 1, wherein said image is converted to grayscale utilizing an image filter.

3. A method for enhancing an image according to Claim 1, wherein said image is of one of the image types consisting of, but not limited to, a GIF image, a bitmap image, a JPG image, a PNG image, a RAW image, and a TIFF image.

4. A method for enhancing an image according to Claim 1, wherein said second threshold is greater than or equal to said first threshold.

FIG. 1


Convert Image to Two-dimensional Array
Convert Image to Grayscale
Divide Image into Vertical Sections
Determine Minimum Pixel Intensity
Process Image Linearly
Reassemble Image
101
103
105
107
109
111

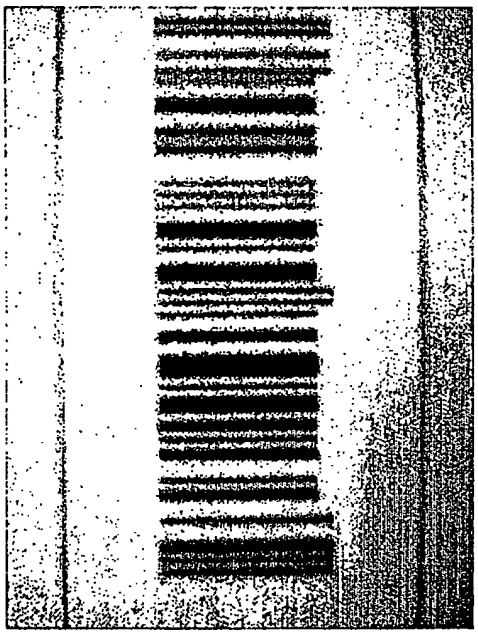


FIG. 2A

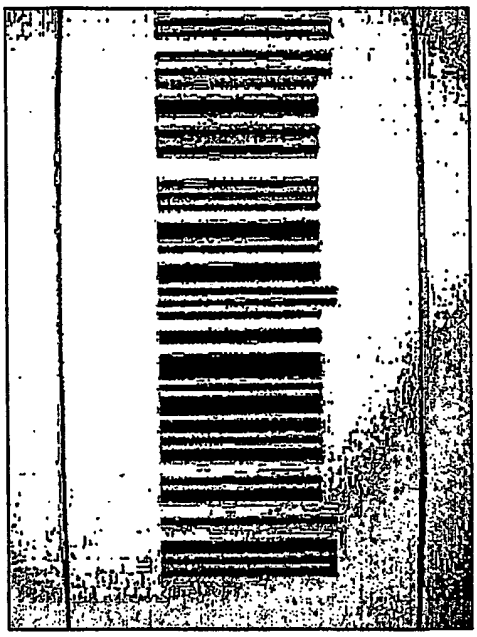


FIG. 2B

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US04/13101

A. CLASSIFICATION OF SUBJECT MATTER
IPC(7) : G06K 7/10, 19/06
US CL : 235/462.01, 462.25; 382/173
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
U.S. : 235/462.01, 462.25; 382/173

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
NONE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 6,091,511 A (BEN DROR et al) 18 July 2000 (18.07.2000), Abstract, Figures 1 and 2.	1-4
Y	US 5,852,677 A (NAKAMURA et al.) 22 December 1998 (22.12.1998), see entire document.	1-4

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

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Date of the actual completion of the international search
14 March 2005 (14.03.2005)

Date of mailing of the international search report
18 MAY 2005

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Form PCT/ISA/210 (second sheet) (July 1998)